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The effects of GeoGebra on students achievement

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Abstract

The rapid growth of technology for learning includes the introduction of educational software. However, rare reports were found that provides evidence on the effectiveness of these software. This study investigates the effectiveness of using GeoGebra software on Mathematics learning among 62 students in Malaysia. Results show that students have positive perception towards learning (m =4.26) and have better learning achievement using GeoGebra ($p < 0.05$). Available free online, GeoGebra can benefit students Mathematics learning and diversifying learning in classrooms. The overflown of resources triggered students' interest to learn Mathematics however, the selection of software has to be properly planned.

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Keywords: GeoGebra software; learning Mathematics; learning performance; educational technology; learning perfomance

1. Introduction

Technology has become one of the powerful resources of learning. The evolution in using technology in teaching and learning process has grown by leaps and bounds. There was a lot of Mathematics software have been developed to aid teaching and learning, including GeoGebra, Geometer's Sketchpad and Mathematica. Several studies have been carried out on GeoGebra software to study various aspects of learning. GeoGebra has become a tool that can help teachers to design effective instructional lessons. GeoGebra not yet widely used in teaching Mathematics in Malaysia. Although, technology has been proven to improve the efficiency of learning. Li (2007) cited that more than 73% of

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the students commented that GeoGebra is found to be a very useful technology for learning. Technology allows easy access to information and other cutting-edge research to make learning easier.

2. Background of Problem

The factors that influence students' attitudes towards Mathematics are the teaching materials used by teachers, classroom management, teacher content knowledge and personality, relating the topics with real life situation (Yilmaz Altun & Olkun, 2010) and teaching methods (Papanastasiou, 2000). Mathematics can be regarded as a challenging subject. Learning Mathematics involves understanding the theories and formulas to describe something. In the typical classroom, the challenge for the students is to explore complex problems. With advances in multimedia technology, learning difficulties can be overcome.

The challenge is more complex in teaching and learning of Mathematics, where teachers have to balance the mental, stationery and digital tools for teaching and learning that involve abstract mathematical concepts that is difficult to be understood by students (Prieto, Sordo Juanena & Star, 2013). Technology plays an important role in the development of the educational process (Gursul and Keser, 2009). Existing technology equipment such as GeoGebra, Geometer's Sketchpad and Mathematica should be used to the maximum by the educators. The use of technology is important because it serves as an object of education, which affect the learning content and objectives, and as a medium to improve the teaching and learning process (Voogt, 2008).

According to Hohenwarter (2008), GeoGebra is a computer program (software) for Mathematics, especially for learning geometry and algebra. Abramovich (2013) defines GeoGebra as a free online software application for the study of geometry, algebra, and calculus at grade level and different teaching. Studies on students' perception on applying technology in Mathematics classes were given less attention (Li, 2007). Therefore, a study on the effectiveness on student achievement GeoGebra has to be conducted to see how it can be beneficial to improve the education system in Malaysia. The second objective of this study was to identify students' perceptions of the use of GeoGebra in learning Mathematics. There is much controversy over the past two decades about the effects of using the tools of technology (calculators and computers) in the teaching and learning of Mathematics (Smith, 2002). Therefore, this study aimed to prove the extent to which technology tools can impact the teaching and learning of Mathematics.

3. Methods

This study applied quasi-experimental research design involving 62 students. Students were divided into two groups of the experimental group and the control group. The experimental group is the group of students were taught about how to use the GeoGebra software to solve Statistics problems. Meanwhile, the control group was given Statistics problems to be solved without using GeoGebra.

The participants of the experimental and the control group were randomly selected. The difference between pre and post- performance test determines whether the GeoGebra software influenced the students' achievement on learning Statistics.

3.1. Research procedure

The research procedure consists of four phases. As shown in Figure 1, the first phase is the pre-achievement tests consist of four questions and carried out simultaneously on the experimental group and the control group. The second phase is the intervention phase of the experimental group by using GeoGebra while the control group was taught using traditional teaching methods (without using Geogebra). Next, the third phase is the post-performance test to both groups after two weeks. After the respondents went through the three phases, the test results will be evaluated to determine whether GeoGebra affect student achievement test results for the topic of Statistics Form 4. At the fourth phase, only the experimental group answered a questionnaire to find out their perception on using GeoGebra.

3.2. Samples

The research sample consisted of Form 4 students at a secondary school in Malaysia. There were 62 samples involved where 32 students will be in the control group and another 30 students were in the experimental group. They were chosen based on two classes of Form 4 in the school. All students involved have studied the topic Statistics. Therefore, they have a basic knowledge about the subject.

3.3. Instrumentation

The instrument used in this study is the performance tests; pre-performance test and post-performance test and also a set of questionnaire. The performance tests were used to compare what they knew before in a pre-performance test and what have they experienced in the post-performance test.

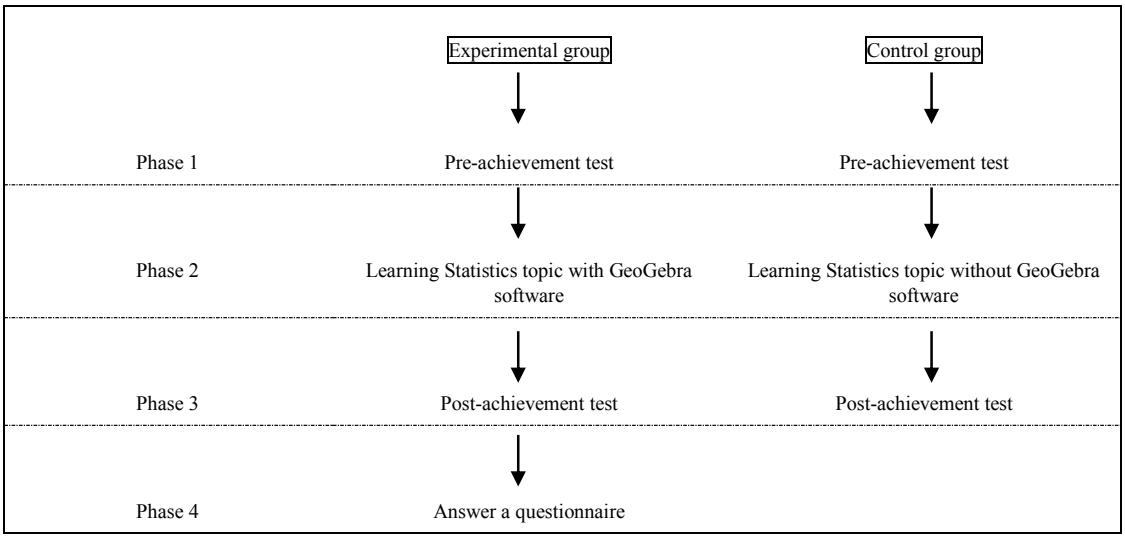

Fig. 1. A summary of the research procedure

3.4. Performance Tests

The pre - achievement test was used to determine the achievement level of achievement by students in both groups. This test consists of four questions to be solved without using GeoGebra software that will be answered by both groups experimental and control groups. Post-performance test contains four questions that have a slightly different with the questions in the pre- performance test, but the question is in the same structure. Post-performance tests used to measure the students' achievement after using GeoGebra software. These tests involved both the control group and the experimental group. These tests are reliable at $r = 0.80$ ($p < 0.05$).

3.5. Questionnaires

This questionnaire contains nine items using a Likert scale of '1-Strongly Disagree, 2-Disagree, 3-May Agree and May Not Agree, 4-Agree and 5-Strongly Agree'. This study used a modified questionnaire based on Shadaan and Leong (2013) study. This questionnaire contains statements which reflect the students' perception of the use of GeoGebra software. The questionnaire is reliable with $\alpha = 0.892$ which indicates good internal consistency.

4. Results and Findings

4.1 Students' achievement in learning Mathematics using GeoGebra

Based on Mann-Whitney U test in Table 1,the difference in the mean scores for the two test results for the two groups of students shows that experimental group performed better than the control group. Based on the findings, it can be stated that the value of $\alpha = 0.00$ ($p < 0.05$) indicated that the using of GeoGebra software has positive impact on students' achievement in Mathematics.

GeoGebra software seems to have a positive effect on the post-performance test conducted on the students. Although the post-performance test scores show a decrease compared to the pre-achievement test, Mann-Whitney U test (Table 1) shows that there are significant differences between the post-performance test on using GeoGebra. As a study conducted by Shadaan and Leong (2013), the results of this study also show that the use of GeoGebra in the learning and teaching process can give a very good impact in improving students' ability.

Reviews by Royati, Ahmad Fauzi and Soul (2010) also show that students in GeoGebra group scored better than students who learn with traditional methods. The results of this study indicate that there are significant differences between the mean scores of students in the post-test for the GeoGebra. Based on their findings, this suggests that GeoGebra is very helpful in the traditional classroom teaching and more effective than traditional teaching. The increment in students' achievements tests scores are likely due to factors of their attraction towards the technology. The development of technology tools increases the student interest to figure out the new thing. The students tend to explore the world of technology to apply it in learning Mathematics.

Table 1. The results of the Mann-Whitney U test.

	N	Mean	Standard Deviation	Minimum	Maximum
Pre-achievement Test	60	77.9333	15.96168	14.00	100.00
Post-performance Test	51	74.0000	17.88072	29.00	100.00
Students	62	1.4839	.50382	1.00	2.00

4.2 Students' perception towards using GeoGebra for learning

The students' perception was identified through a set of questionnaire consists of nine items. The questionnaire was distributed to the experimental group only to know their perception based on their experience using the GeoGebra software. The results gained from the questionnaire show positive results.

The study found that the items in the questionnaire that had the lowest mean was the item which stated that students can think creatively and critically with a mean of 3.93. While the highest mean is 4.62, which is obtained for the first item: 'I like using GeoGebra'. Based on Table 2, the overall mean is 4.26. It shows the overall students agreed with positive statements about GeoGebra. Students also found that GeoGebra can also give a good impression of their learning in Mathematics class. From the results, it can be concluded that the using of Geogebra software can increase students' interest, confidence and their motivation in learning Mathematics.

Table 2 shows the highest mean of the questionnaire is the first statement:"I like to use GeoGebra software". These students had never used GeoGebra before. Probably these are the reasons why they enjoyed using GeoGebra software in learning Mathematics. Lunar et al., (2010) stated that the use of computers in teaching and learning is not only to improve student performance, but also motivation. Based on Fig. 2 and Fig. 3, students who responded strongly agree shows the highest percentage compared to other responses. This shows that the students' interest in using GeoGebra software in learning Mathematics. In the study by Noorbaizura and Leong (2013), they found that learning process experienced by the experimental group (using GeoGebra), allows them to communicate openly with the teachers and students and among the students themselves. It shows that learning with software could also trigger on-tasks interactions. The interactions as a result of learning increased students' interest in learning Mathematics.

Table 2. Table of the mean of questionnaire.

Item	Minimum	Maximum	Mean	Standard Deviation
I like to use GeoGebra software	3	5	4.62	0.561
GeoGebra software helps to learn Mathematics concepts	3	5	4.22	0.641
I feel confident when do the activities by using GeoGebra software	3	5	4.10	0.618
I learnt a lot about Mathematics when using GeoGebra software	2	5	4.21	0.819
I can think creatively and critically when using GeoGebra software	2	5	3.93	0.842
I prefer to learn Mathematics with GeoGebra software	1	5	4.28	0.996
I am excited when asked to explore the GeoGebra software	3	5	4.31	0.761
GeoGebra software can help to increase my achievement in Mathematics	3	5	4.25	0.752
I am happy if the teacher uses the GeoGebra software in teaching Mathematics	1	5	4.45	0.948
Overall mean			4.26	

Students may take advantage on the used GeoGebra software in learning Mathematics because they can interact with technology. Students in the 21st century are computer-literate and the opportunities to learn using technology support will attract major attention. They use the Internet, cell phones, computers, laptops, tablets and other software to communicate with others. Digital environment motivates students in the teaching and learning of Mathematics (Korenova, 2012). It also encourage both teachers and students to engage in learning and teaching (Ozdamli, Mus and Nizamoglu, 2013). At present, many scientific studies show that computers have made it easier not only to understand mathematical concepts, but also enhance students' motivation and self-confidence (Yenilmez, 2009).

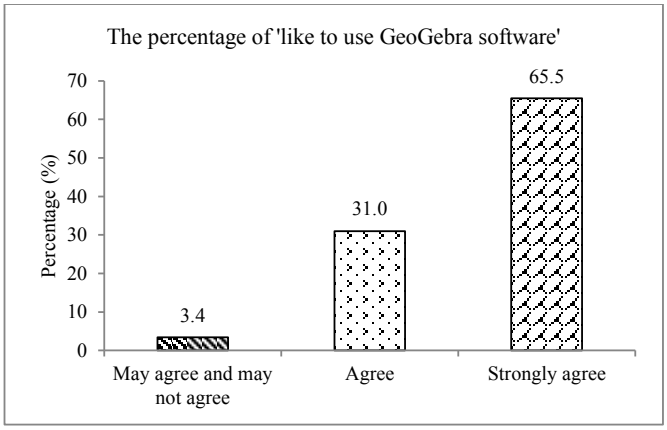

Fig. 2. The graph of the percentage of 'like to use GeoGebra software'.

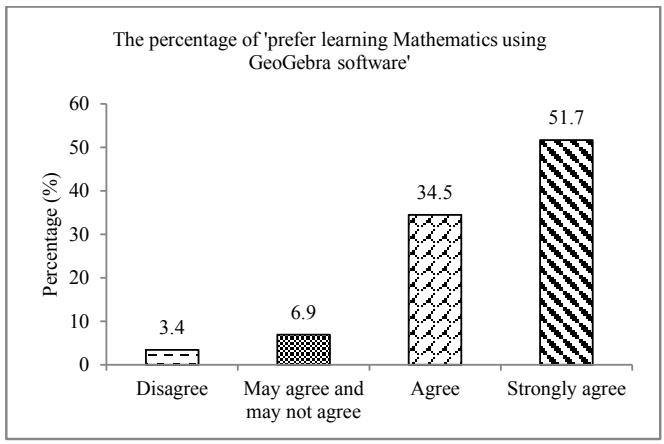

Fig. 3. The graph of the percentage of 'prefer learning Mathematics using GeoGebra software'.

5. Conclusion

Learning and teaching of Mathematics should not be focused on purely theoretical, but also a variety of learning approaches that involve the use of teaching aids proven to help stimulate students' interest in Mathematics. The Mathematics software available in the market or even online has facilitated the task of the teacher to impart knowledge beneficial to the students. However, it depends on the teacher to utilize existing materials without the need to allocate extra time to developed other teaching aids.

Conclusively, this study has shown that GeoGebra software has a positive impact on students' achievement in the topic Statistics. The students also have positive perceptions on GeoGebra software in terms of enthusiasm, confidence, and motivation. This software should be introduced to Mathematics educators so that students can explore the world of Mathematics in a wider and make the students able to think critically and creatively.

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